



Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

A vertical black and white photograph of oat plants. The image shows several long, slender leaves and developing oat heads (spikes) on thin stems. The background is dark, making the lighter-colored plant parts stand out.

OATS for GRAIN and FORAGE

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Oats are in an economically favorable position in California. A breakthrough in breeding experiments has resulted in improved yields and disease-resistant varieties. The amount of horse racing in the state, and a rapid increase in number of saddle horses near the large cities, have provided a good market for well-grown, top quality, pure oat hay and grain oats.

California's oats are grown principally for forage (about 400,000 acres), usually hay; a small portion is cut green and either fed as green chop or ensiled; the rest is harvested for grain (about 180,000 acres). In some seasons, as many as 100,000 acres of wild oats are also cut for forage.

Oats for grain are used almost exclusively for livestock feed. They are often fed whole to horses and sheep, are usually ground for dairy cattle, and rolled for rabbits. Oats are also used extensively for poultry, usually without hulling. The hulls appear to be rich in food factors that check certain phases of malnutrition in chickens—those that induce feather picking and cannibalism. (In nutrition experiments with rats, oat proteins promoted a more rapid rate of growth than did the proteins of any other grain.) Practically none of the California oat grain crop is used for human consumption, primarily because there are no oat mills in the state.

When oats are cut in the 20 per cent

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GRAIN and FORAGE

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flowering stage and properly cured, they make a very palatable and highly nutritious hay relished by all classes of livestock. About 20 per cent of the oat hay crop is grown in combination with vetch or Canadian peas, providing a legume-carbonaceous forage.

Oats are one of the best crops for use in the rotation system on dry-farmed barley or wheat land because they help to reduce root rot losses. The organisms that cause "take all" and other similar root diseases in barley and wheat do not thrive on oats. In California experiments, and in field practice, grain yields per acre have been increased up to five-fold by incorporating oats in the dry-farm grain cropping system. As a consequence, oats are increasingly being incorporated into grain crop rotation systems.

Production records for each of the best-known varieties of wheat, oats, and barley have been kept at Davis for 24 years (1934-1957). The average yields in pounds per acre, were as follows: Atlas barley, 3,025; Kanota oats, 2,586; White Federation wheat, 2,595. During three of the 24 seasons, Kanota was a complete failure from shattering, rust, or lodging. Neither barley nor wheat failed completely in any season. Oats gave the highest yield per acre in five seasons, wheat in three, and barley in 13. With the new variety, Indio, outyielding Kanota by an average of 28 per cent in recent tests, it is safe to expect average

oat grain yields practically to equal those of barley in areas in which Indio is adapted.

Oats produce satisfactory crops on a wide range of soil types, provided the soil is well-drained and reasonably fertile. The crop does best on clay loam or loam. Oats do well on the red terrace soils ranging from Butte County southward through Stanislaus County. They are also grown extensively on the adobe soils of the Montezuma Hills of Solano County.

In California, oats are grown principally in the central and south coast districts, and in the Sacramento and San Joaquin valleys. Climatically, oats are best adapted to the cooler, coastal regions. Hot, dry, windy weather just before heading causes blast, particularly in the common white oat varieties. Such weather during the heading and ripening period causes oats to ripen prematurely, with poorly filled grain of light bushel weight. By turning to shatter-resistant and earlier maturing red varieties (such as Indio and Palestine), however, growers have shown that profitable grain and hay yields are possible in the drier, hotter interior valleys. Oats are more susceptible to winter frost injury than are other small grain crops. Prolonged periods of temperatures below 22° F will kill some California varieties. The nature of the oat head (panicle) is such that it is especially vulnerable to shattering by wind.

How to Identify Current Oat Varieties

Commercially, oats are generally classified according to color of the matured, unweathered grain. The colors usually recognized are black, red, gray, yellow, and white. (Red, as referring to oats, is usually a reddish-yellow rather than a distinct red, best characterized by the variety California Red.)

Oats also may be classified into three convenient botanical groups: wild oats (*Avena fatua* or *A. barbata*); the arid-region red oats (*A. byzantina*); and the cool- or humid-region white oats (*A. sativa*). The red oat varieties tend to endure more winter frost, mature earlier, and suffer less damage by heat and drought than do the white oats. As a result, our highest yielding and best-adapted varieties are red. Currently available true white varieties are adapted only to the cool, northern mountain counties. They often produce "blasted" panicles when grown in the warm central valleys.

Oat plants can be distinguished vegetatively from other cereals by the distinctive attachments of their leaves and stems. The main characteristics are the

total absence of clasping auricles, a more prominent ligule, and a throat. These parts of the plant, and others, are shown on the following diagrams. A typical oat spikelet (Palestine variety) is also shown, with its main parts identified.

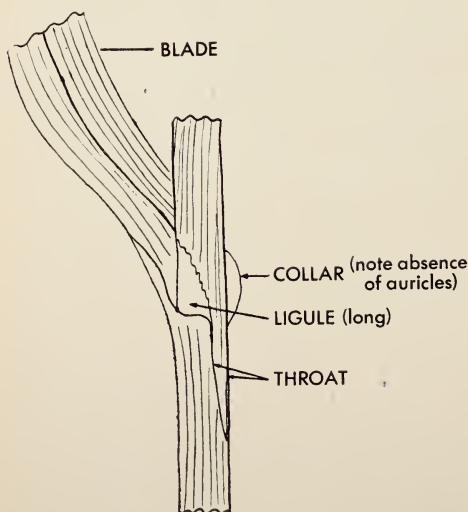
The six leading oat varieties in California, described below, are listed in the order of their introduction into California agriculture.

Coast Black

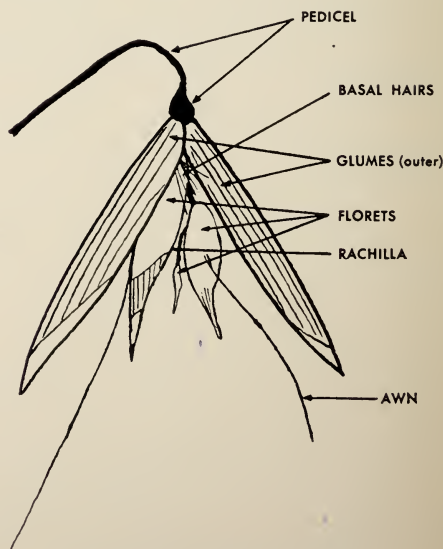
History. An early introduction, once widely grown for hay. Present culture is confined to north-coastal counties.

Description. Plants tall, coarse, with large leaves; very late-maturing; winter habit (poor heading from summer sowing). Moderately resistant to stem rust. Seeds black, heavily hulled, and generally of low bushel weight.

Recommended use. Only where climate is cool, rainfall abundant, soil heavy, and a late-maturing hay is desirable.

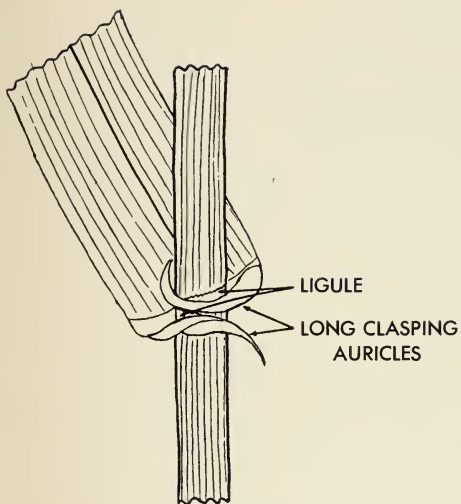


Oat leaf and stem.

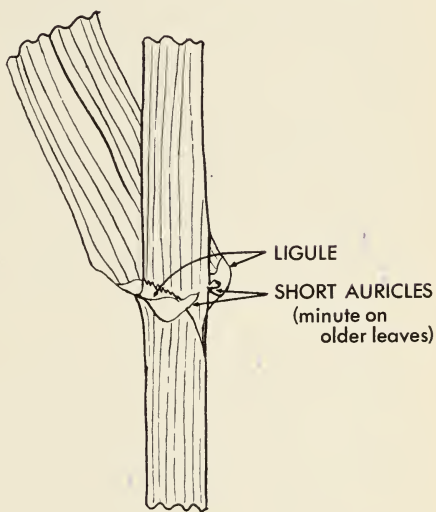


Oat spikelet (Palestine variety).

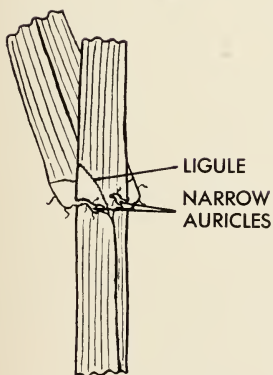
**DIAGRAMS SHOWING SIDE VIEW OF THE
COLLAR REGIONS OF OTHER GRAINS**



BARLEY



RYE



WHEAT

(All line drawings by Beecher Crampton, Botanist, Agronomy Herbarium, Davis.)

California Red

History. A strain of Red Rustproof, once a dominant variety in the south central states. Numerous introductions, particularly of "Texas Red," were made. Not all present-day stocks are identical. The majority, however, trace to a mass purified stock first released by the University of California as foundation seed in 1937.

Description. Plants tall, fine-stemmed, leafy, liberally pigmented with purple; late maturing, with a rather strong winter habit. Although moderately resistant to stem and crown rust, California Red is the most susceptible to yellow dwarf virus of any California oat variety. Seeds generally deep-colored, prominently awned, and of medium weight.

Recommended use. Better suited for hay than for grain production. Recommended where winters are cold or the soils are excessively wet. Should never be sown in late winter, because of the yellow dwarf virus hazard, or where heat and drought are severe.

Kanota

History. A selected strain of Fulghum released by the Kansas Agricultural Experiment Station. Following extensive testing of Fulghum and Kanota, certified seed of Kanota was released in California, in 1928, where it soon became the leading variety. Recently, newer varieties have pushed it into a subordinate position.

Description. Plants tall, coarse, sparsely leafed, and frost-hardy. Seeds are plump, tend to shatter, have only occasional small awns. Relatively early heading. More tolerant of yellow dwarf virus than any variety grown in California.

Recommended use. Its maturity range and stiff straw make it very satisfactory for sowing with vetch. When allowed to mature for grain, crop should be windrowed to minimize shattering

losses. Should not be grown in areas subject to rust, which often reduces quality of hay or yield of grain.

Palestine

History. A strain of Indian or Calcutta collected in Palestine during World War I, reselected at the Werribee State Research Farm in Australia, introduced to America in 1926, and first grown at Davis in 1932. First released to farmers in California in 1940. Despite extreme susceptibility to rust, Palestine has produced 28 per cent higher average grain yields than Kanota, and 34 per cent more than California Red during the 1934 to 1956 period at Davis and in statewide tests from Imperial to Tehama counties. It proved to be the best variety where heat, wind, or drought are severe.

Description. The earliest, shortest, and most shatter-resistant of the California varieties. Highly susceptible to all of the major oat diseases, and is most easily killed by frost. Kernels long, thin, with prominent awn and a high percentage of hull.

Recommended use. Useful at present only in the more arid and warmer parts of the state and where adequate supplies of Indio have not yet been accumulated. Indio will soon displace Palestine.

Ventura

History. Ventura was selected from the cross, Victoria-Richland x Fulton. The latter came from a Fulghum x Markton cross. The U. S. Department of Agriculture and the Kansas, Iowa, and Idaho experiment stations shared the major responsibilities in breeding Ventura. The California Experiment Station sponsored its release here in 1943.

Description. Plants shorter, more leafy, and later maturing than Kanota. Seeds yellow-white, awnless, and considerably smaller than those of other California varieties. Highly resistant to most races of stem and crown rust and covered smut generally found in California; sus-

(Continued on page 10)

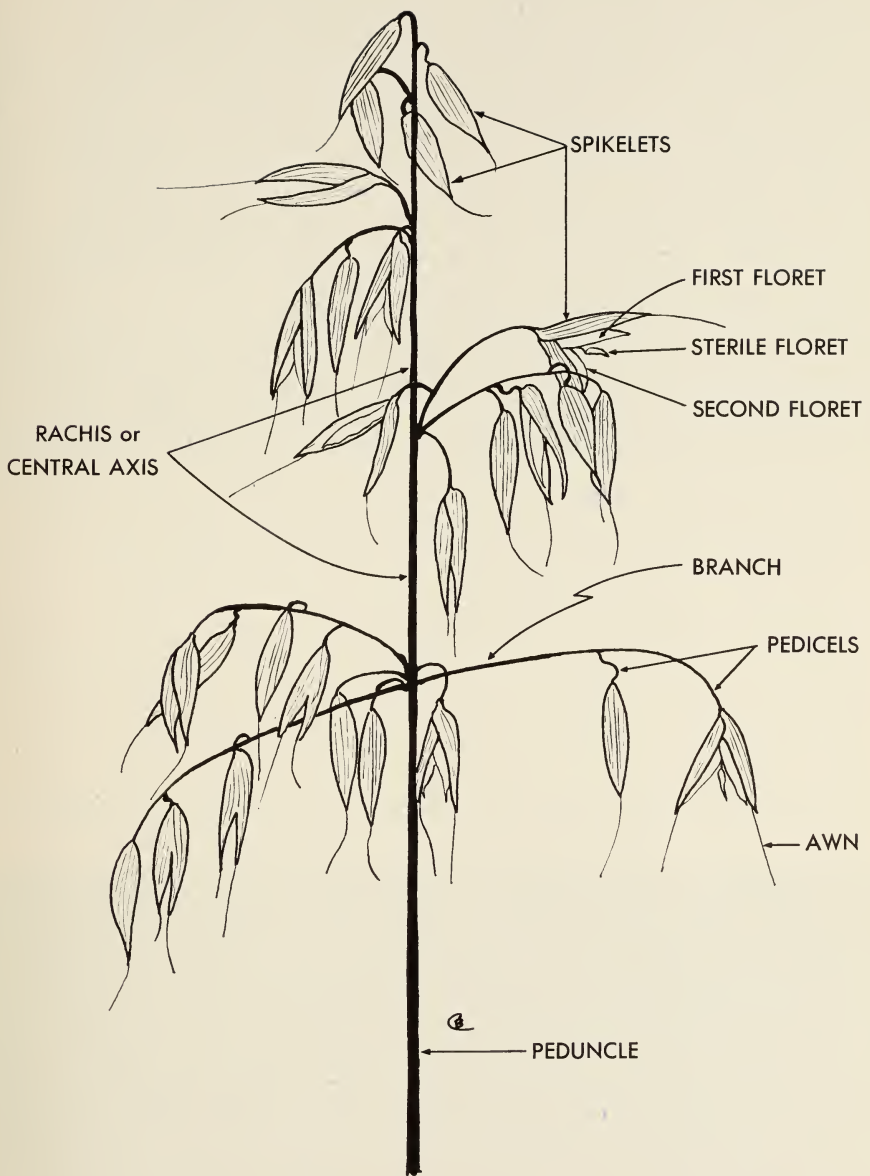


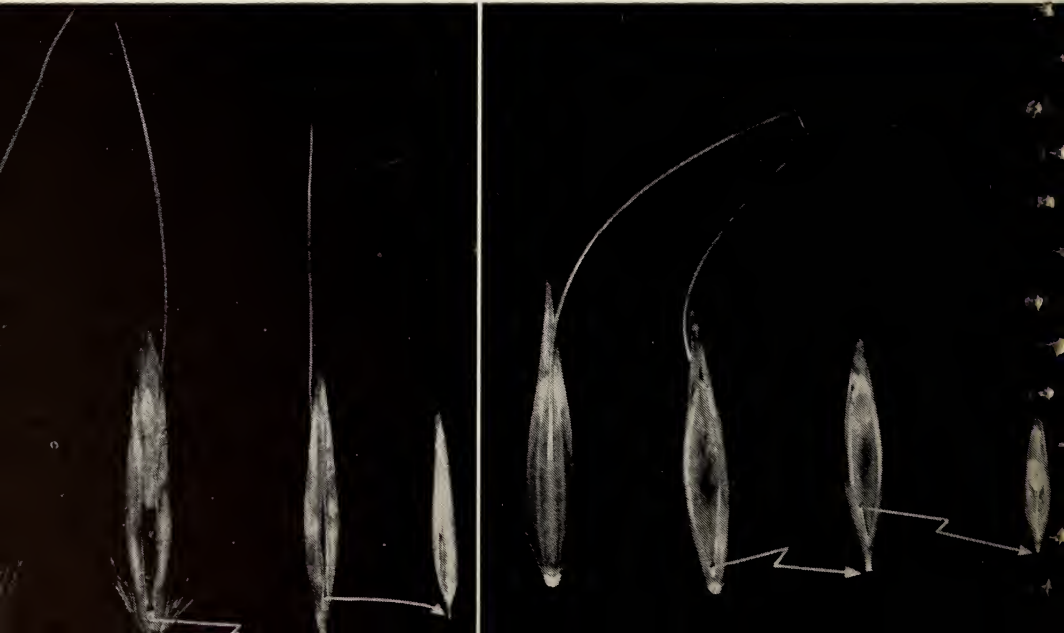
Diagram of oat panicle, showing major parts.

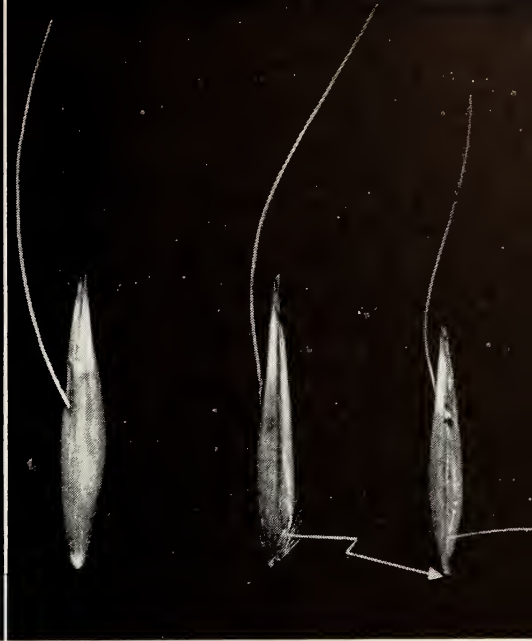
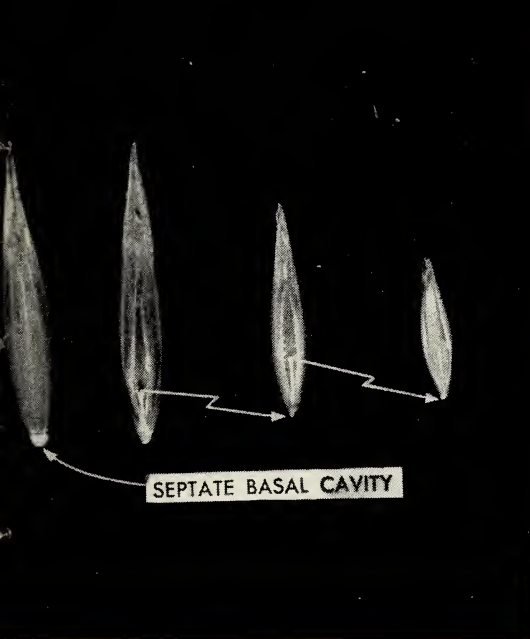
Most oat varieties can be identified by examining the seeds and heads (panicles). This may be done with aid of a simple botanical key which describes the various parts. The diagram (p. 7) identifies the parts; the keys that follow describe each of the varieties now commercially important in California, and the wild types.

Key to Cultivated Varieties:

- A. Hull dark-colored, lower floret with fairly well-developed basal cavity; rachilla usually persistent to upper florets.
 - B. Hulls black or grey*Coast Black*
 - BB. Hulls brownish red to red.
 - C. Awns weak to prominent, usually present on both the outer and inner floret.
 - D. Awns prominent; basal hairs rather numerous; glumes long-pointed*Palestine*
 - DD. Awns prominent; basal hairs sparse*Indio*
 - DDD. Awns weak; basal hairs few; glumes short*California Red*
- AA. Hull light-colored, yellow to reddish-yellow; lower florets separate by fracture; upper florets easily separated from rachilla.
 - B. Occasional awns on outer grain; septate basal cavity*Kanota*
 - BB. No red color in hulls; awns seldom present; small seeds*Ventura*

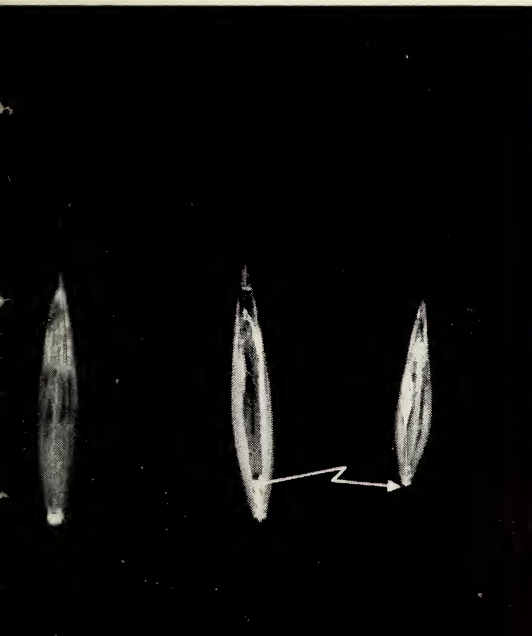
Left: Coast Black variety. Note black seed, basal hairs, and rachilla fractures. Right: florets of California Red, showing fracture of rachilla. (See diagram, p. 4.)





Left: florets of Kanota oats, showing irregular fracture at bases of upper ones, and septate basal cavity. Right: florets of Palestine variety, showing fracture of rachilla. (See diagram, p. 4)

Left: Ventura variety florets showing irregular fracture at bases of upper ones. Right: florets of Indio; arrows indicate fracture of rachilla.



Key to Wild Species:

The common wild oat has taller, more vigorous plants than the cultivated varieties, and strongly twisted, geniculate (bent or kneed) awns. The grain from all florets has a pronounced sucker mouth at the base, and usually a very hairy lemma. The hull color may be white, grey, red, or black.

- A. Lemmas (hulls) terminate in two long bristles*Avena barbata*
- AA. Lemmas terminate in two short teeth*A. fatua*

False wild oats, or fatuoids, occasionally appear in cultivated oat fields. They are true intermediates. They resemble either the common wild oat or the cultivated variety in certain respects. These fatuoids are the result either of natural crossing with wild oats and other cultivated oat varieties or of natural mutation in the cultivated varieties. Self-pollination is normal in oats, but natural crossing may occur occasionally between wild or other oat varieties. Oats naturally cross more frequently than does barley or wheat.

ceptible to Helminthosporium blight—a disease not yet observed in the state.

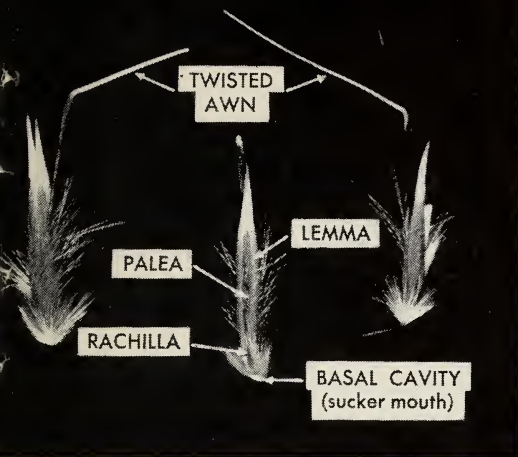
Recommended use. One of the best choices at present for security, in either hay or grain production, in areas commonly subject to rust. Ventura hay is of top quality. It is believed that this variety will give way to rust-resistant forms of Indio and Kanota as they become available. (Since seeds are small, about 25 per cent less, by weight, should be sown per acre.)

Indio

History. A sixth backcross cycle selection, isolated from the crossing of a Victoria-Richland and Fulghum hybrid with Palestine. Indio is a product of the coöperative oat improvement project conducted by the University of California and the U. S. Department of Agriculture.

Description. Essentially all of the plant characteristics of Palestine have been put in Indio, plus resistance to some of the prevalent California races of crown and stem rust and the advantage of more than one pound in test weight over the Palestine parent. Indio and Palestine have produced almost identical yields where rust was absent or sparse. The yield advantage in favor of Indio has averaged 38 per cent where rust was serious. Severe injury from yellow dwarf virus may occur in late-sown fields. Lodging is likely to occur in thick stands.

Recommended use. In all winter-sowing areas of the state except at elevations over 1,500 feet. Indio winterkills at temperatures of 20° to 22° F. California's highest yielding grain variety, it is equal to the best tall variety in hay-yielding ability. Indio matures too early to use in combination with vetch for hay.



Wild oats (*Avena fatua*). Note twisted awns. Florets easily separate at their bases, the upper one with no irregular fractures.

Table 1. Comparative Performance of Principal Oat Varieties at Davis, 1934–1957*

Data	No. of years observation	Variety			
		Calif. Red	Kanota	Palestine	Ventura
Production data:					
Grain yield (lbs./A.)	21	2,400	2,586	2,976	2,656†
Highest yield	1	4,224	4,416	5,248	4,736
Lowest yield	1	608	1,216	1,152	1,088
Test weight (lbs./bu.)	19	32.0	36.3	30.5	34.5
Growth comparisons:					
Pasture readiness in early spring‡	8	86	100	115	108
Date headed	19	May 4	Apr. 20	Apr. 15	Apr. 25
Height (inches)	15	50	49	41	48
Damage situations:					
Lodging (per cent)	7	39	59	35	32
Shattering (per cent)	4	24	62	10	29
Frost (per cent)	4	5	2	20	7
Disease reactions:					
Stem rust (per cent)	13	15	33	50	tr
Crown rust (per cent)	5	12	35	51	0
Mildew (per cent)	7	6	23	25	13
Halo blight (per cent)	3	2	1	14	5
Yellow dwarf (per cent)	1	73	3	45	42

* Tests in 1935, 1936, and 1944 were "failures."
† Grown only 14 years.
‡ As per cent of Kanota.

How to Choose the Right Variety

High yielding ability and the plant's resistance to disease and rust should be considered when choosing an oat variety. A shatter-resistant variety, such as Indio, should be grown in a windy area if the crop is to be harvested for grain. A rust-resistant variety, such as Indio or Ventura, should be grown in a district having a history of cereal rust. In a district where yellow dwarf virus has been a problem in cereal crops, Kanota may be the safest variety because of its tolerance for that disease.

Time of sowing also affects the choice of variety. Early-maturing varieties, in general, do best in the drier, hotter areas of California, and for late sowing. Late-maturing varieties are best adapted to the cooler areas and to those where winter growth is restricted by too-wet soils.

A comparative characterization of four California oat varieties is given in table 1. The frequency of occurrence in the table gives an indication of the relative importance of diseases, frost, lodging, and shattering as observed in experiments at Davis. The comparative relations here shown are roughly applicable

wherever oats are winter sown in California. For growers, these factors plus yield and the varietal description (pp. 4-10) are basic for the choice of a variety. None of the varieties is universally the "best." Though it has been mentioned elsewhere that Kanota has coarser stems than California Red, the variety has lodged more severely at Davis. Since it heads two weeks earlier and rain-wind complexes are more common in early April, this is not an inconsistency. The late winter growth score is an estimate of comparative growth in February, and has an application in a single pasturing.

Varieties of oats show less variation in hay yields than in grain yields. For hay, the critical choice often concerns quality instead of yield. In Southern California considerable dry-farmed acreage produces less than 1 ton of hay per acre, while yields of 5 tons are sometimes obtained in the north, under more abundant rainfall or irrigation.

For Grain

Table 2 shows the grain yield of the six leading oat varieties in the key areas of California. Since most of the state's

Harvesting from the swath. Oats are ready to thresh when grain is down to 10 to 20 per cent moisture.



grain oat crop moves as livestock feed, the variety recommended for any given district would normally be the one yielding the most grain.

For Forage

Recent hay trials conducted by the Department of Agronomy and University of California Farm Advisors have shown that all of the current California oat varieties, when grown and harvested under comparable average conditions, yield about the same total amount of forage per acre. For example, although Kanota grows later and taller, it yields no more total dry matter per acre than does a short, early variety like Palestine. The greater basal leafiness of the shorter types apparently compensates for the greater height of the taller varieties. The choice of oat varieties for hay should therefore be based upon desired time of maturity, strength of straw, hay quality, and available moisture.

For many years, California ranchers considered the California Red variety best for haymaking. In the absence of rust or yellow dwarf attacks, it produces a high-quality, fine-stemmed hay, if properly handled. Recently, it has been largely displaced by Ventura, a rust-resistant variety that is also fine-stemmed and leafy, and that yields hay of considerably better quality than does California Red in years of rust attack. Stockmen have favored Kanota for growing with vetch. Kanota is fairly tolerant of yellow dwarf virus, to which California Red is extremely susceptible; it matures at about the right time for growing with purple vetch; and its strong straw provides good support for the climbing vetch crop. When sown together, the oats usually mature to the medium to hard dough stage when the purple vetch is in full bloom.

Table 2. Comparative Grain Yields of California Oat Varieties (Average of all Farm Advisor Tests, 1929-1957) *

Test area	Coast Black			California Red			Ventura			Indio†			Palestine		
	No. of tests	Average yield	Yield as % of Kanota	No. of tests	Average yield	Yield as % of Kanota	No. of tests	Average yield	Yield as % of Kanota	No. of tests	Average yield	Yield as % of Kanota	No. of tests	Average yield	Yield as % of Kanota
Southern California	3	14.9	43.0	52	30.6	68.6	66	bu/A	bu/A	2	10.1	109.8	82	47.0	120.5
San Joaquin Valley	..			56	33.1	77.5	63	37.4	87.2	2	91.9	139.0	63	61.2	129.9
Sacramento Valley	2	16.7	43.7	41	36.2	90.9	40	44.3	96.3	4	83.8	134.3	39	49.1	132.3
Central Coast.	3	59.6	83.3	100	41.1	81.7	90	44.5	114.4	3	83.6	108.4	57	57.2	122.5
North Coast and mountains.....	5	38.8	80.7	16	34.8	80.9	21	53.3	103.9	3	24.3	97.6	26	55.0	118.8

* Associates who participated in development of these data include G. A. Wiebe, F. N. Briggs, C. W. Schaller, L. L. Davis, and many University of California Farm Advisors.
† Not available for tests until 1956.

Growing the Crop

The cultural practices recommended in this section are essentially the same whether oats are grown for grain or forage.

Seedbed Preparation

A good seedbed for oats should be semicloddy on the surface but firm beneath. Crusting may be a problem on overworked soils with a fine powdery surface. Soil compaction may result from working soils when they are too wet, or from repeated use of a single tillage implement.

Fallow operations. The bulk of the California oat crop is grown without irrigation, in the foothill areas of the Central Valley and in coastal districts. In the low-rainfall areas (less than 15 inches annually), it is a common practice to fallow the land and grow a crop of grain or cereal hay every other year. Proper fallowing will control wild oats and other weeds, perhaps help retain some moisture in the soil, and increase the availability of plant food to the following crop. A typical fallow tillage operation would be two heavy and two light cultivations, with a light summer weeding tillage in some seasons.

The number of fallowing operations and type of tool used will vary with soil type, amount and time of rainfall, and the terrain. Equipment for the heavy or initial operations includes an offset disk, a wheatland plow, and a chisel or, in some areas, the moldboard plow. The heavy operations should be performed as early as possible, usually in the fall or early winter. This will work crop residues and fall-germinated weeds into the soil, insuring their decomposition and improved availability of the resulting plant nutrients. The second heavy working, in the late winter or early spring of the next year, will kill wild oats, other weeds, and volunteer grain. The offset disk and chisel are the best implements

for these operations on hillside soils. Where land is level or only slightly rolling, the wheatland plow is commonly used and, in some areas, the moldboard. The advantages of the disk and chisel are that less soil is turned over, and straw and stubble are mixed on or near the soil surface, providing protection against rain and wind erosion.

Two or more light workings carried out in the spring are primarily weed- and volunteer-control operations. Equipment includes tandem disks, springtooth harrows, or CC cultivators and rod weeders. The amount of crop residue, soil conditions, and plants to be killed will determine the tool to be used and the number of times over a given field. In some areas a single tillage will suffice.

It is advisable to till the soil across the slope on land subject to erosion. In such soils the use of the chisel, CC cultivator, and rod weeder is recommended because these tools tend to keep crop residues at or near the soil surface. All of these practices will aid in reducing rainfall runoff, improving moisture penetration, and reducing wind and rain erosion.

Dry-farmed annual cropping. In districts where rainfall and other conditions permit seeding oats on other than summer fallow, the tillage program will generally be much shorter. Usually the stubble of the preceding grain crop will have been grazed by stock in July, August, or September.

In marginal rainfall areas where stock is not available, the preceding crop residue may be burned off rather than grazed. Burning stubble land is not recommended except where weeds may be a serious problem or where the crop has been heavily diseased. Consistent unnecessary burning of stubble hastens the depletion of soil resources. Some counties now have antiburning ordinances (applying to agricultural land as well as

urban areas) as smog-control measures.

The first or heavy mechanical operation should be with a wheatland plow, moldboard plow, or, in some cases, an offset disk, early in the fall. This operation should be performed while the soil is dry, if possible. Following the first rain, a light working with a disk or springtooth harrow will usually make a good seedbed. In some districts, especially in the foothills of the Central Valley, the finishing operations in November or December are done with a Graham plow followed by a spiketooth harrow.

Bur clover and wild oats volunteer profusely in the fall and winter in some areas, particularly the central coastal district. For this reason it may be advisable to wait until these have germinated well before finishing the seedbed preparation. Otherwise the seeded oat crop may be choked out by weeds or badly contaminated with wild oats.

Irrigated districts. The method used depends upon the previous crop, the soil condition, and whether or not the grain will be irrigated up. Plowing usually is necessary following alfalfa or irrigated pasture. This operation may be followed by several diskings. Following vegetable crops or cotton, disking twice works the crop residue into the soil and tills the soil to a depth of 5 to 7 inches. The field should be floated and bordered after the seedbed is prepared. The grain may then be drilled and irrigated up. An alternative and preferred practice is preirrigation, usually followed by harrowing, after which the seed grain is drilled.

Seed

Buy seed of the best quality available. By purchasing certified seed of the appropriate variety you will be assured of top quality seed that meets high standards of purity and germination, and is free of weed seeds. Moreover, it will reproduce the varietal characteristics for which it was selected.

The cost of seed is only a minor part of the cost of growing the crop. You are not economizing by using cheap seed. Common seed (uncertified) frequently can prove most expensive, even if the initial cost is low. In a recent experiment, it was found that samples of common cereal seed taken from farmers' drill boxes contained as high as 2,000 weed seeds per pound. In many instances the samples contained noxious weeds such as morning-glory, star thistle, and whitetop. To use such seed is literally to seed your fields to noxious weeds that could cost thousands of dollars for control measures. Planting common grain that has not been cleaned to remove weed seeds and shrunken grains is a hazardous, costly practice that no progressive farmer will follow. If you have to reseed a field because of low-germinating seed, your seed costs may be doubled or trebled, and your farming costs increased.

Seed dormancy. This is common to most cultivated red oat varieties. Dormancy is a physiological seed condition wherein seed fails to germinate satisfactorily for a brief period immediately following harvest. Storing freshly harvested oat seed for a period of four to six weeks before planting will correct this condition. Low germination caused by storage of damp seed or thresher damage, however, will not be corrected.

Seed treatment. Treating oat seed with an effective chemical fungicide is recommended for the control of seed-borne diseases such as covered and loose smuts, *Helminthosporium* leaf blotch, and bacterial blight. Organic mercuric fungicides such as Ceresan M, liquid Ceresan, or Panogen are recommended. Follow the manufacturer's recommendations as to rate of application and treating procedure.

When buying seed, check the bag labels to see if the seed has been treated. Seed does not have to be treated with a fungicide in order to be sold as certi-

fied quality. Once grain is treated with a poisonous fungicide, it cannot be used safely for any purpose other than seed, except after other costly treatment. For this reason, seed growers and dealers may treat the seed they distribute only on request of the purchaser. The important thing is to be sure the seed you sow has been treated, either by the dealer or by you, but not both.

Time to Sow

The best time to seed oats either for grain or hay in California, at elevations below 1,500 feet, generally is late November, December, or early January. In the mountainous areas, the crop should be seeded as early in the spring as a seedbed can be prepared and after the danger of prolonged freezing weather is past.

Oats thrive best in cool weather; they suffer heavily from heat or drought. Therefore, it is desirable to sow early enough that as much as possible of total crop growth is completed during the rainy season.

Seeding at the times recommended above will minimize yellow dwarf virus problems. Oats seeded much before November 15 or after January 15 are usually damaged much more severely by this disease.

If early-maturing varieties like Indio or Palestine are seeded before November 1, they may be heading out or blooming

when winter frosts occur in February or March. Seeded as recommended, the early varieties usually will not head until after the average date of the last killing frost.

Seeding at the time recommended for your area contributes to maximum yields. Your local Farm Advisor can tell you the best dates. Seeding tests at Davis show the importance of time of sowing (table 3). Grain yields suffered when seeding was much after January 1. Observations over the state show that grain yields are also reduced by frost, lodging, and yellow dwarf virus disease, as results of too early seeding. Similar observations have been made on oats sown for hay or silage.

Rate of Seeding

Rate of seeding depends upon date, method, variety, fertility, moisture, and competition from weeds. Because late-seeded oats tiller (stool) less than those seeded from November 15 to January 15, about 15 to 20 per cent more seed must be used per acre to achieve satisfactory grain or forage yields with late sowing. Seeding oats too heavily can lower grain or forage production. Excessively dense stands promote disease and lodging, with a resulting low yield. Broadcast seeding by airplane or endgate seeder requires 15 to 20 per cent more seed per acre than is required when a seed drill is used. In broadcasting, some

Table 3. Effect of Date of Seeding on Yield of Oats

Crop year	No. of varieties grown	Actual seeding dates			Acre yield in bushels (32 pounds per bushel) at following seeding periods:		
		Nov.	Jan.	Feb.	Optimum	Mid-winter	Late
1939.....	3	11	..	25	87	..	45
1941.....	5	27	31	..	53	34	..
1942.....	3	19	..	16	103	..	28
1947.....	4	29	2	..	71	84	..
1948.....	4	22	5	..	46	31	..
1949.....	4	11	7	..	133	116	..
1950.....	4	15	..	18	102	..	77

of the seed is lost because it is not covered enough to protect it or else it is covered too much. The following are generally recommended seeding rates for various situations:

CROP	DRILLED	BROADCAST
	(optimum seeding conditions) pounds	(after Jan. 15, below 1,500 ft.) pounds
Grain or hay	48-64	64-96
Oats-vetch hay:		
Oats	48	48
Vetch	48	48

The recommended seeding rate for oats and vetch varies, depending on how well vetch grows in a particular district, and the product desired. Where nearly pure vetch hay is the goal, from 10 to 20 pounds of oats and about 65 pounds of vetch may be used. In general, most districts seed a 50-50 mixture of oats and vetch seed, at rates varying from 60 to 100 total pounds of seed per acre, depending upon seeding time. The lower rates are used for early seeding; the higher for late seeding.

Fertilization

The kinds and amounts of fertilizer to use profitably depend upon soil type, soil moisture situation, length of the growing season, native fertility level, and the cropping history of the field on which the oats are to be grown. Local Farm Advisors usually have a set of crop fertilization recommendations and can suggest fertilizers for oats or oats and vetch.

On most soil types in the dry-farmed grain areas, the application of about 20 to 40 pounds of nitrogen (100 to 200 pounds of ammonium sulfate or its nitrogen equivalent) has resulted in profitable increases in grain and forage under usual moisture conditions. Where oats and vetch are grown together, the nitrogen fertilizer may be reduced or omitted.

On sandy soils, or those subject to heavy leaching, it may be desirable to

apply one-half of the nitrogen fertilizer (as ammoniacal N) at seeding time and the remainder as a top dressing (as nitrate N) when the crop is 4 to 6 inches tall, a stage at which rapid growth and large demands for nitrogen occur. Nitrogen applied after the jointing stage has less effect on yield but may influence the quality of the crop.

Under irrigated conditions, grain or forage yields of oats can be increased with liberal amounts of nitrogen, ranging from 20 to 80 pounds of actual nitrogen per acre. If considerable straw or nonlegume crop residue is incorporated in the soil shortly before seeding the oats, it may be desirable to supply an additional 20 to 40 pounds of nitrogen to offset the temporary nitrogen deficiency during the crop residue decomposition. Little or no supplemental nitrogen may be needed where the oats follow alfalfa, irrigated pasture, heavily fertilized row crops, or legume green manures.

Phosphorus fertilizers have given economical responses on some poorly drained, old terrace or plains soils with strong claypan or hardpan development. Such soils include the Corning, Kimball, Hartley, Huerhuero, San Joaquin, Rocklin, Aiken, Linne, and Altamount. Some older alluvial soils (Delano, Ducor, Ramona) in the floor of the Central Valley are borderline deficient and may respond to phosphorus application under continuous heavy cropping.

Phosphorus needs can be determined by test strips across a field and, in some instances, by soil analyses by a commercial laboratory. The sodium bicarbonate (NaHCO_3) method of testing for available phosphorus has usually proved satisfactory. Your local Farm Advisor can assist in interpreting the laboratory report. Analyses will usually be made on the basis of pounds of available P_2O_5 per acre. Cereal crops usually respond to added phosphorus when the NaHCO_3 -extractable phosphorus is less than 30

pounds P_2O_5 per acre. If phosphorus is needed, the equivalent of about 20 to 60 pounds of P_2O_5 per acre, either as a combination nitrogen-phosphorus fertilizer or as single or treble superphosphate may be applied. Oats or oats and vetch for hay have shown responses to phosphorus fertilizers in some dry-land areas.

When phosphorus is needed, it should be applied with the nitrogen at seeding time. Fertilizer containing phosphorus preferably should be drilled, but may be broadcast and then disked or harrowed in so that it is placed several inches below the surface.

Some growers mix the seed and fertilizer and drill them together. This practice is definitely risky where the rate of fertilizer application exceeds 150 pounds per acre, and it may injure the seed or seedlings at rates as low as 100 pounds per acre. Experiments in California and elsewhere with foliar spray applications of urea or other nitrogen solutions to cereal crops have not been particularly promising.

In University of California field trials to date, cereals have shown some response to sulfur and possibly to zinc, but little to potassium and none to elements other than those mentioned above.

Harvesting the Crop

For Grain

The bulk of California's grain oat acreage is cut and swathed before it is threshed. Ripe oats are likely to shatter, particularly under strong winds. Swathing the oats before they are dead ripe avoids losses from shattering and stem breakover or crinkling. Trouble from green weeds is also eliminated by swathing. The grains have reached full development in the hard dough stage. If satisfactory drying weather prevails, the windrows will be ready to thresh with

Irrigation

Most of the California oat crop is grown without irrigation. In most districts of the state, on good, deep, permeable soils, there probably would be no increase in forage or grain yields as a result of irrigation, if the annual rainfall is 15 inches or more, and is well distributed. In dry-farmed districts where average annual rainfall is less than 15 inches, and especially if it is poorly distributed, the crop should either be sown on fallow, or irrigated.

If oats are grown in a very dry area or season, a total of about 15 to 17 acre-inches of water from rainfall and irrigation will be required for good yields. Thus, one or two irrigations of about 6 acre-inches each may be needed. Critical moisture periods for the oat plant occur when it is about 4 to 6 inches tall, and again when it is in the boot stage. Tillering (stooling) and head formation are taking place when the plants are about 6 inches tall. The greatest water usage occurs when the oat plants are in the boot stage. For maximum yields it is important to maintain a continuous supply of available soil moisture either by rainfall or irrigation, especially during the critical periods.

a combine with a pick-up attachment in three to seven days after swathing.

For direct-combine harvest, the grain must be fully ripe. This is feasible where winds are not heavy and/or where farmers are able to harvest the oats as soon as they are dry. Normally, the crop is ready for direct combining when all green has left the straw, the seed is down to about 10 to 12 per cent moisture, and the chaff has turned a dull white. Short, stiff-strawed Indio or Palestine combine with less shatter and crinkle loss than

do the taller growing California Red, Ventura and Kanota varieties.

Storage. For safe storage, grain oats should be down to 12 per cent moisture content or less. If the threshed grain contains much green trash, it should be removed promptly to avoid high moisture and spoilage of the grain. Place grain for storage in clean, sound, weather- and animal-proof structures, in order to avoid quality deterioration and resulting monetary losses. Oats weigh less than do other types of grains, such as barley or wheat; therefore, pound per pound, they require from 60 to 100 per cent more storage space. The hull of the oat grain ordinarily makes up 25 to 40 per cent of the total grain weight.

For Hay

Oat hay is most nutritious if cut when most of the plants have headed and some of them are shedding pollen. In studies just completed at Davis, by the departments of Agronomy and Animal Husbandry, stages of maturity were described and associated with the feeding value of various oat hays. Chemical analysis, digestion trials, and feeding tests with sheep were used to evaluate the hays fed.

Seven stages of development, representing the entire forage production period, were harvested as follows:

STAGE OF DEVELOPMENT	APPROXIMATE HEIGHT inches
59% jointing	15
16% flag leaf	23
21% boot	27
1% flower	30
18% flower	38
44% milk	44
42% dough	46

The lignin and holocellulose content increased steadily during the growing period until the milk stage. Total digestible nutrients (TDN) in the oat forage decreased slowly from a high of 68 per cent in the flower stage. Thereafter, a rapid decrease occurred, to 50 per cent in the milk stage. This was followed by an upturn to 53 per cent in the dough stage when the grain was increasing rapidly in dry matter.

Yield of total dry matter per acre increased to the end of the milk stage, but remained constant thereafter. There was about a 10 per cent increase in dry matter between the 18 per cent flower stage and the 42 per cent dough stage. Animal

Left: combine harvesting of oats near Willows, California. Because ripe oats shatter easily, combine harvesting is risky in windy areas. Right: swathing oats near Hemet, California. Grain will finish maturing in swath and be ready in three to seven days if weather is dry.



nutrient yield, however, as indicated by total digestible nutrients and lamb production per acre, was greatest at the 18 per cent flower stage.

Early gains by the experimental sheep were influenced very little by stage of maturity up to the milk stage, at which point there was a drastic decrease in gain. *Sheep receiving hay cut at the 18 per cent flower stage produced approximately 800 pounds of gain per acre of hay as contrasted with slightly over 600 pounds of gain on hay cut at the 42 per cent dough stage.*

These results indicate that oat forage should be harvested when the plants are in the flowering stage, but if that is not possible, delay cutting until the dough stage.

For Silage and Green Chop

Oats or oats and vetch (less frequently) are harvested green from the field as green chop or for ensiling. The choice of varieties, methods of growing, and harvest timing for green chop vary tremendously, depending on whether interest is in gross yield or TDN.

Pasturing Oats

Oats can be used to bolster winter livestock pastures (usually deficient from late November through January). The Kanota variety, which is tolerant of yellow dwarf virus, should be used for such early seeding. When seeded in late September or early October at elevations below 500 feet, the crop will usually be ready for grazing by late December. If the crop is not grazed when the soil is very wet, a succession of grazings, a hay crop, or perhaps even a grain crop can be obtained later in the season. In tests conducted by the Riverside County Farm Advisor, October-sown oats have provided up to three cuttings from a single planting when harvested each time at a height of about 15 inches. Heavy fertilization and irrigation before seeding and

Some growers have made good oat silage by the "wilted" method, but the best silage generally results where ensiling additives are used. The following have given good results when evenly mixed with each ton of green chop going into the silo: about 75 pounds of stock feed molasses; or 10 pounds of dehydrated molasses; or 125 pounds of barley; or 8 pounds of sodium bisulfite (use only in airtight silo).

SPECIAL SITUATIONS

Drought may result in accumulation of nitrates in immature oats. If plants are cut at the 18 per cent bloom stage, the hay may be somewhat toxic to certain types of livestock. Excessively high levels of nitrogen fertilization may give similar results. Therefore, in years of short rainfall, or under unusually high nitrogen levels, for maximum safety, do not cut drought-stressed oat hay before plants are in the medium dough stage. This is important where livestock, and especially horses, are to be fed oat hay exclusively.

immediately after each harvest during the late spring are usually necessary for maximum pasture production.

Oats sown for grain production can be grazed moderately under good management in the early vegetative stage without a serious reduction in yield. Adequate soil moisture and fertility stimulate new growth after the field has been grazed. *Pasturing after the plants begin to joint usually results in reduced grain yield, but good yields are possible if the stock are withdrawn before that stage and if adequate moisture and plant nutrients are available.* Oats should not be grazed while the fields are wet. Some growers graze or clip oats after the jointing stage when frost damage or severe

lodging occurs. The plants then head late in the spring and are short. Satisfactory regrowth after late clipping is possible

only where moisture and fertility are adequate and when temperatures are moderate.

Weed Control

Two types of weeds are troublesome in oat fields: (1) grassy weeds, such as wild oats, darnel, and ripgut; and (2) broad-leaved weeds, such as wild radish, mustards, star thistle, fiddleneck, and wild sunflower. The first group can be controlled by well-timed seedbed preparation; the second, by chemical means.

Wild oat infestations are difficult to control because the seeds shatter readily and are subsequently plowed under or trampled into the soil. They may lie dormant in the soil for several years, but will germinate and grow when they are returned to the surface by later cultivation. Wild oats were introduced into California during the Mission period, as a contaminant in barley, wheat, and oat seed. Especially well-adapted to California's climate, they spread rapidly over most of the state in contaminated grain and hay. Wild oats volunteer so profusely on cropped and uncropped land in many areas of the state that they frequently are harvested for hay.

Wild oats and other troublesome annual grassy weeds can be controlled by delaying final seedbed preparation until fall or winter rains have germinated the seeds that are at or near the soil surface. Disking or harrowing will then kill most of the weedy grass seedlings, and the seeded crop will become established before the weeds are again abundant. This practice is also useful in controlling broad-leaved weeds. In some coastal areas of California the grain fields are so weedy that several diskings during

the winter are necessary. Seeding is then delayed until early spring.

Most of the commonly occurring broad-leaved weeds can be controlled by spraying weedy oat fields with selective chemicals, such as amine 2,4-D or MCP. Use $\frac{1}{2}$ to $\frac{3}{4}$ pound of active chemical per acre, applied in 3 to 15 gallons of water by airplane or 15 to 50 gallons by ground rig. Oat plants should be 4 to 6 inches tall, and tillering, when treated. This crop should not be sprayed after jointing has begun.

Oats are more susceptible to injury from 2,4-D than is barley or wheat. For this reason, some farmers prefer to use MCPA which is less injurious to oats. Where very resistant weeds, such as fiddleneck, predominate, the low-volatile ester formulations of 2,4-D or MCP, at the rate of $\frac{1}{4}$ pound active chemical per acre, may prove more effective than the amine formulations, but may result in more injury to the oats.

In some areas, especially where the chlorinated types of herbicides are restricted by law, the dinitro compounds are used to control seedling weeds in oats when the crop is from 4 to 6 inches tall. Follow the manufacturer's recommendations as to amount and method of applying dinitro herbicides.

Growers using 2,4-D or MCPA, under provisions of the law, must first obtain a permit from their local Agricultural Commissioner.

Diseases and Insect Pests

Diseases

The fungi and viruses causing the major oat diseases in California are trans-

mitted from field to field or plant to plant in various ways. They may be carried by air, rainwater, soil, and seed, or trans-

mitted by insects. Thus, the control of these diseases is often largely dependent upon how they are spread. Many of the diseases that affect cultivated oats also affect wild oats, and are spread from the latter to the cultivated varieties in many areas.

Stem rust, caused by a fungus, is the most common and often the most serious disease of oats in California. Since the fungus and spores may be found throughout the year on cultivated oats, wild oats, volunteer oats, and other closely related grasses, a source of infection is often present when weather conditions are favorable for development. Epidemics occur in cultivated oats when temperatures and humidity in late winter and early spring are above the average normal for California oat-growing areas. A heavy rust infection will cut grain yield and quality severely.

The disease may be recognized by elongated pustules of brick-red spore masses that break through the leaf surface and result in a ragged margin of host tissue around the spore mass. Infection and sporulation may occur on leaves, leaf sheaths, stems, and flowers. These spores are spread by wind, and infect other plants during periods of high relative humidities and warm temperatures. Late in the growing period of the plant, black spore masses may be produced in place of the red spores. Control of this disease is largely dependent upon growing the resistant varieties Indio and Ventura.

Crown rust, caused by another rust fungus, attacks the leaves and occasionally the leaf sheaths, but does not infect the stems. The fungus produces small, orange-yellow spore masses in compact groups. In many years, the disease may affect sufficient leaf area to result in loss of hay quality and grain weight.

The black spore stage is found on older leaves, in small pustules covered by leaf tissue. The red spores from wild

and volunteer oats constitute the initial source of infection for cultivated varieties in the early spring. The only practical means of control is to grow the semi-resistant varieties, Ventura or Indio. The latter has been found infected in some areas of the state where unusual races of the rust are present.

Loose and covered smuts are most common at present in wild oats. They have become rare in California cultivated varieties since the use of organic mercury seed treatments. Evidence of smut is not present in the plant until heading time, when the fungi produce black spore masses which replace the normal flower parts. These spores are air-borne to surrounding, healthy flowers, and are also disseminated to healthy seeds at the time of threshing. The spores or minute amounts of mycelium are carried on or near the surface of the seeds, and become active when the seed is planted. The fungus grows into the growing points of the seedling, and eventually produces the spore masses.

Powdery mildew has not been a serious disease of cultivated oats in California, but occurs extensively on wild oats throughout the state. It is identified by gray to tan masses of fungus growth on the leaves. These masses are easily removed by rubbing. Spores produced on this growth are air-borne, and infect during periods of high humidity and cool temperatures. Infection may be severe enough to reduce yield and quality of oat hay. No control measures are practiced.

Helminthosporium leaf blotch has been present in California for many years, and reached epidemic proportions in the upper Sacramento Valley in 1956, 1957, and 1958. The fungus attacks only oats. It is characterized by the appearance of red-brown to almost purple oval spots on the leaves. As the fungus progresses through the tissues the spots become elongated and irregular in outline and light brown in color. Multiple infections result in death of leaves, with

lower leaves affected first. Infections may reach the upper leaves and floral parts when frequent periods of rain occur through the spring. The primary infection of a plant results from the seed-borne phase or from air-borne spores produced on refuse from a previously infected crop or on wild or volunteer oats in the immediate area. Organic mercury seed treatment will control only the seed-borne phase. Rotation with another crop for one year will eliminate most of the carry-over on plant refuse in the soil.

Halo blight, a bacterial disease, is most common on the varieties Palestine and Indio. It attacks only oats. Infection occurs on leaves and floral parts, resulting in oval spots, at first water-soaked, with a yellow margin, and later with a tan center. The bacteria may be carried in crop residue for one year or may be seed-borne. The latter type of infection can be controlled by use of an organic mercury seed treatment.

Root rot may be caused by several different soil-inhabiting fungi, but oats rarely suffer severely from attack. Wheat and barley are much more susceptible to these fungi. The disease is characterized by brown to black discoloration at the base of the stems. This invasion by the fungi may kill the plant at any time from shortly after heading to normal maturity. Plants are often killed in small, scattered spots or in irregularly shaped areas several hundred feet across. Wild oats and other weeds usually grow luxuriantly in such spots. Oats are sufficiently tolerant of attack to be used in rotation where the disease has become a major factor in wheat and barley. When planted following a year of oats, barley or wheat will often show markedly less root rot than when they follow barley or wheat.

Yellow dwarf virus causes disease in wheat, barley, oats, and many wild and cultivated grasses. It is transmitted from diseased to healthy plants during

the feeding process of any one of several species of grass-inhabiting aphids. Very early (October 1) or very late (February 15) plantings usually are most severely damaged, because aphid populations are generally higher in early fall or late spring. In oats the disease results in dwarfing, and an orange to red discoloration of the leaves, in contrast to a yellow discoloration in wheat or barley. The leaf reddening starts at the tips of the older leaves and progresses to the base, with orange-red blotches preceding the over-all reddening. At heading time, blasting of basal flowers of the panicles may be evident. When high percentages of infection occur during the young plant stage, yields may be reduced by as much as 70 per cent. The varieties Coast Black and California Red are the most susceptible to injury, and Kanota is the most resistant variety. Timing the date of planting, and using varieties with some tolerance are the only practical means of control.

Blasted panicles are ones with varying degrees of withered or empty florets. They may result from unfavorable climatic conditions or from yellow dwarf virus. This condition reduces the number of seeds per head, and may reduce yield. Although seen in red oats, the condition is much more common in white-seeded varieties imported from cool climates.

Insect Pests

Rarely have insect pests appeared in California oat fields in sufficient numbers to make chemical control economically practicable. Despite the fact that at least five species of aphids transmit yellow dwarf virus, it has rarely paid to control them by chemical treatment. If insects appear to be damaging your oat crop, ask your local Farm Advisor whether treatment is necessary.

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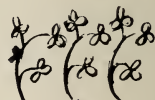
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